RAFFERTY-ALAMEDA PROJECT

ENVIRONMENTAL IMPACT STATEMENT

Souris Basin Development Authority

CHAPTER 14

FISHERIES

RAFFERTY/ALAMEDA ENVIRONMENTAL IMPACT STATEMENT

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FISHERIES

1.0 ENVIRONMENTAL SETTING

1.1 General Description of Riverine Habitat

The Souris River arises in the southeast corner of Saskatchewan, loops through northern North Dakota and returns to Canada in the Province of Manitoba where it discharges into the Assiniboine River southeast of Brandon. Four general types of riverine environment are present within the Souris River mainstem in Saskatchewan (Pierce and Blood 1977).

Information regarding fisheries utilization of the Souris River habitat is taken from Pierce and Blood (1977), as well as from the results of sampling conducted during the spring of 1987. A data report documenting the results of the 1987 fisheries program is appended to this document. Significant discrepancies exist in the results of the two studies, and these are attributed to blockages of fish movements along the Souris River. In high-water years, such as occurred at the time of the study conducted by Pierce and Blood (1977), fish movements throughout the basin likely were not impeded. However, due to a series of low water years prior to the 1987 study, fish migrations in the basin have apparently been precluded. Where differences in abundance and distribution were noted between the two sampling programs, these discrepancies are addressed in the following discussion.

The Yellowgrass Ditch and Souris River north of Weyburn are intermittent streams, and consist primarily of drainage ditches (Figure 1). No permanent populations of fish are therefore present in this region of the river. The presence of flat, marshy habitat in the headwaters of the system, near Cedoux and Colfax, has been described as providing excellent spawning habitat for some spring-spawning species during spring floods (Pierce and Blood 1977). The upper reaches of the river are used as migration routes to attain this habitat, notably by northern pike **(Esox lucius)** from Nickle Lake. It appears that many fish are stranded in this headwater area after the spawning

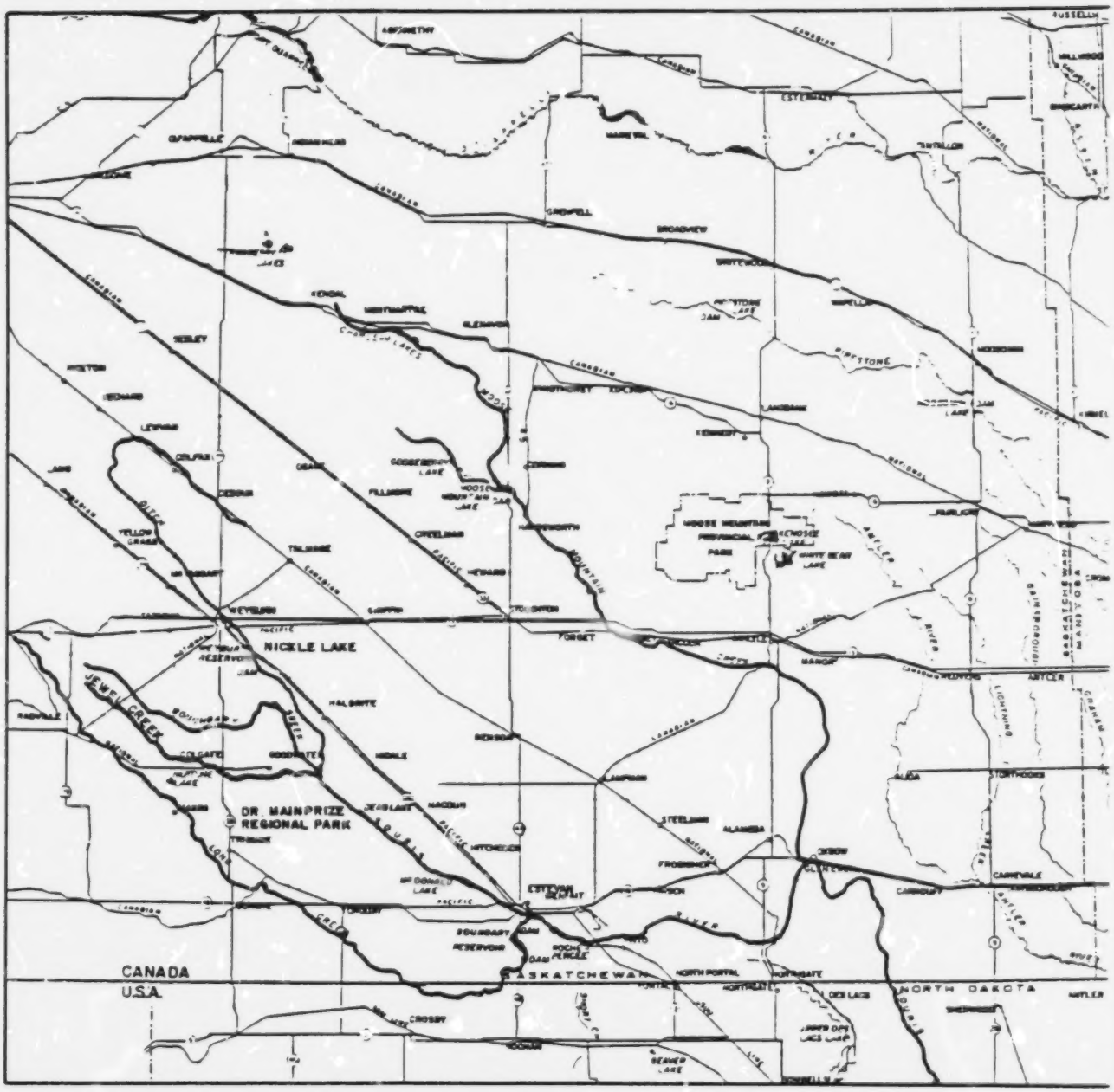


FIGURE 1

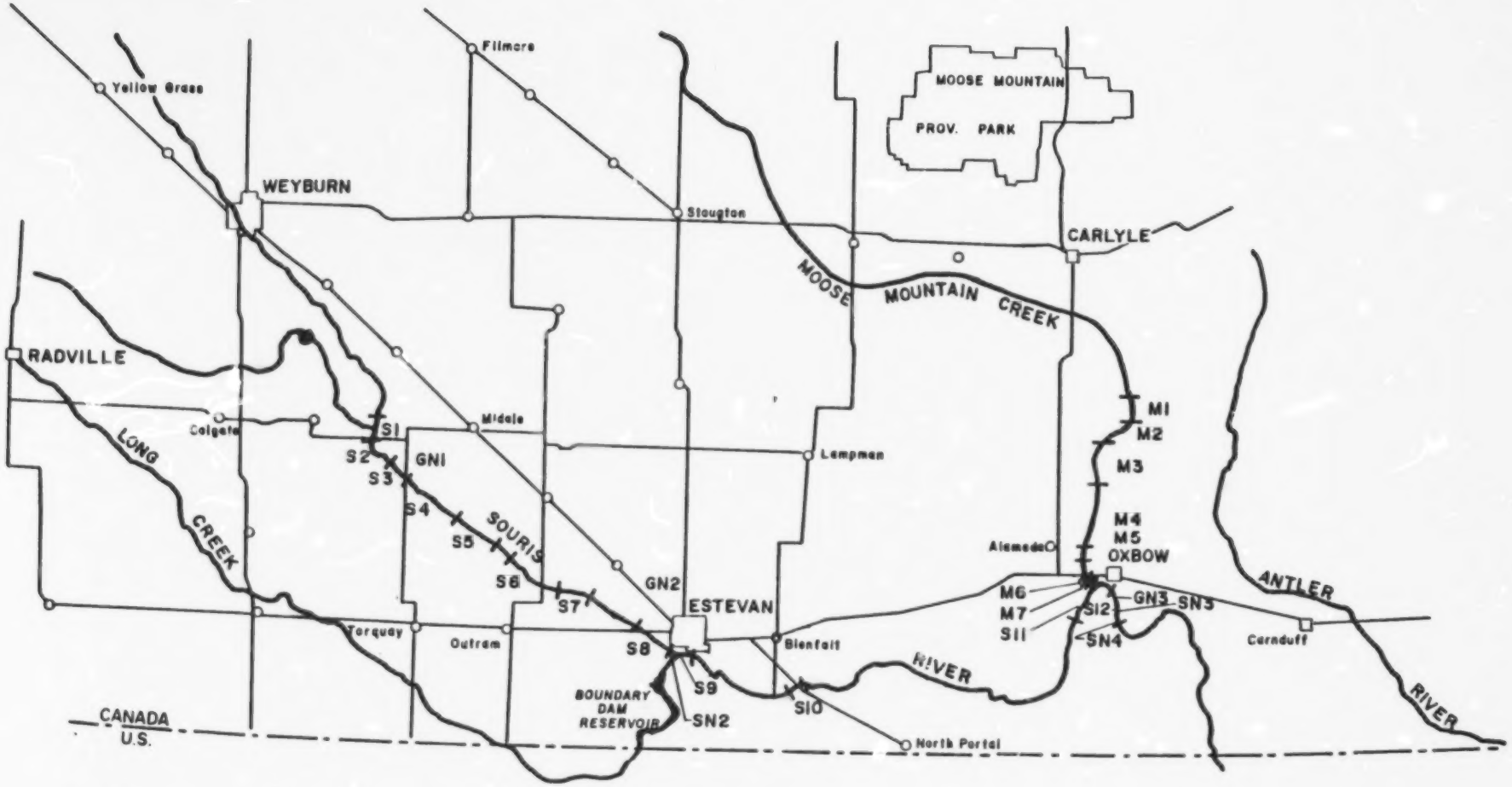
SOURIS RIVER STUDY AREA
IN SASKATCHEWAN

season, as a result of low or no flow in the river marsh. Areas which drain into the Yellowgrass Ditch are anticipated to experience very low dissolved oxygen levels during the winter months, and thus fish trapped in this region of the basin are subject to winterkill (Pierce and Blood 1977).

Between Weyburn and Estevan, the Souris River flows through a large valley with relatively gentle, sloping sides. Two reservoirs, Nickle and Dead Lakes, have been created in this region of the river. Nickle Lake is an onstream storage reservoir, situated southeast of Weyburn, which has a surface area of 445 ha, a maximum depth of 9.0 m and a mean depth of 3.4 m at the Full Supply Level of 563.0 m (Saskatchewan Water Corporation 1987). Northern pike, yellow perch **(Perca flavescens)**, and walleye **(Stizostedion vitreum vitreum)** are the game fish present in this reservoir, with the latter species being stocked by the Fisheries Branch of Saskatchewan Parks, Recreation and Culture. White sucker **(Catostomus commersoni)** are also abundant in Nickle Lake. The walleye population is apparently subject to winterkill and must be maintained by stocking (Pierce and Blood 1977).

Between Nickle Lake and Dead Lake, as well as downstream of Dead Lake to the vicinity of McDonald Lake, the Souris River is a slow-moving, meandering, prairie river which ranges in width from 10 to 30 m, and often has a depth of 4 m to 5 m in a u-shaped river channel (Pierce and Blood 1977). The river substrate is primarily silt, with gravel and cobble occurring in the few riffle areas present. Pierce and Blood (1977) reported that fish were abundant in this region of the river, with black bullheads **(Ictalurus melas)** being the dominant species. Northern pike is the principal sport fish present, although walleye and yellow perch are also numerous. Forage species noted by these authors in this region include white sucker, trout-perch **(Percopsis omiscomaycus)**, fathead minnow **(Pimephales promelas)** and common shiner **(Notropis cornutus)**.

Sampling during the spring of 1987 revealed that fish populations between Nickle and McDonald Lakes had been significantly reduced (Figure 2 illustrates the location of fish sampling in 1987). A very small number of walleye (14 in total) and northern pike (10 in total) were captured in this region of the river. The only other sport species present was yellow perch.



LEGEND

S(1-12) SOURIS RIVER SAMPLING LOCATION

M(1-7) MOOSE MOUNTAIN CREEK SAMPLING LOCATIONS

SN(1-4) SEINING LOCATIONS

GN(1-3) GILL NETTING LOCATIONS

SOURCE: EMA CONSULTING LTD.

FIGURE 2

FISHERY SAMPLING LOCATIONS
SOURIS RIVER BASIN
APRIL 1987

No adult bullheads were collected, although some juveniles were present. The only species presently abundant in this region of the river are fathead minnows and brook stickleback **(Culaena inconstans)**, which are both very hardy species. Neither trout-perch nor common shiner were collected upstream of Estevan, but one additional species, Iowa darter **(Etheostoma exile)** was recorded. The apparent reason for this decline in the fishery resource is the lack of recruitment from lower reaches of the river, due to blockages at the CPR weir in Estevan and at the weir at Oxbow, and the likelihood of winterkill (or summerkill) of these isolated populations. Some evidence of winterkill was apparent during the spring survey in 1987, as dead black bullhead fry were noted along the periphery of the river during that survey. It appears that repopulation of this region of the Souris River occurs when water levels are sufficiently high to enable fish to ascend downstream weirs and dams. These fish are subject to harvesting pressure from anglers, and the more devastating effects of summerkill or winterkill, such that the population is essentially eliminated when lower water levels prevail. This theory was discussed with several residents of the basin, and these individuals confirmed a cyclic nature in fish abundance in concert with high and low water years.

Dead Lake, an offstream storage reservoir, is located approximately midway between Weyburn and Estevan. The reservoir lies in a meltwater channel which runs parallel to the Souris River Valley, with the dam situated at the confluence of the two valleys. This impoundment has a surface area of 69 ha, a maximum depth of 4.0 m and a mean depth of 2.9 m (at Full Supply Level) (Pierce and Blood 1977). Water levels in the reservoir are relatively stable, usually fluctuating less than 1 m throughout the year, except during periods of heavy spring runoff.

The Dead Lake shoreline is relatively stable, with considerable rock and gravel present (Pierce and Blood 1977). Yellow perch and northern pike are the most abundant sport species present in this waterbody, although walleye are occasionally taken by anglers. The latter species is stocked in Dead Lake by the Fisheries Branch. White sucker and black bullhead are also reported to be very abundant in this waterbody (Pierce and Blood 1977).

From the vicinity of McDonald Lake downstream to Estevan, the river widens to form a large marsh covering most of the valley bottom. During the spring of 1987, the extent of aquatic macrophyte growth in some of these marshy areas was such that no river channel was apparent. Whereas northern pike have been reported as numerous in this region of the river (Pierce and Blood 1977), only one was collected in this area in 1987. This species was more abundant near the City of Estevan, immediately above the CPR weir. Very small numbers of yellow perch were also present in this marshy region of the river (a total of three was captured). The utilization of this potential northern pike spawning habitat would be restricted due to the land-use practice of damming the river in the spring for the purpose of back-flooding the valley, to stimulate forage crop production (hay) on the valley bottom. The dam observed in 1987 would have precluded access by northern pike to approximately one-half of this habitat. The existence of a small population of northern pike, yellow perch, and several rough and forage species (black bullhead, white sucker, brook stickleback, fathead minnow) immediately upstream of the CPR weir would be facilitated by discharges from Boundary Reservoir, which enter Long Creek and the Souris River immediately above the weir.

The remaining reach of the Souris River in Saskatchewan extends from Estevan to the United States Border where the river meanders through a wide, steep-walled valley (Pierce and Blood 1977). The banks of the river are often heavily wooded, and in these areas much of the river is completely shaded. The river is typically greater than 2 m deep and exhibits many deep pools in this reach. The only areas of rapids or riffles occur at road crossings of the river. At least two significant blockages to fish movements were noted in this region of the river in 1987; a rock weir near Roche Percee, and a major dam at Oxbow. The fish fauna reported as present in this segment of the river include northern pike, perch, walleye, black bullheads and white sucker; in addition, rainbow trout **(salmo gairdneri)** are occasionally taken by anglers (Pierce and Blood 1977). During surveys conducted in 1987, neither walleye nor rainbow trout were located in this segment of the river. Forage and rough fish species collected in this area included brook stickleback, fathead minnows, common

shiners, river shiners **(Notropis blennius)**, emerald shiners **(Notropis atherinoides)** (which had not previously been reported in the Souris River in Saskatchewan), johnny darters **(Etheostoma nigrum)**, blackside darters **(Percina maculata)** and longnose dace (**Rhinichthys cataractae)**.

Fish movements within this segment of the river are also contingent upon prevailing water levels in the river. In particular, the dam at Oxbow appears to be the largest obstacle to upstream (and downstream) movement of the fish fauna.

1.2 Tributary Habitat

There are four major tributaries to the Souris River within this Study Area. Roughbark and Jewel creeks enter the Souris River between Nickle and Dead Lakes. Both creeks have very little flow in their headwaters except during spring runoff. The lower reaches are heavily wooded, with gravel bar, riffle and deep-pool habitat present. A small, relatively deep reservoir is present in the upstream region of Roughbark Creek. This reservoir has supported walleye in the past, and has been subject to winterkill (Pierce and Blood 1977). The reservoir was stocked with walleye in 1986 (Fisheries Branch stocking records). The only other species reported present in this waterbody is white sucker. The downstream reaches of Roughbark and Jewel creeks have been reported to be used for spawning by both northern pike and yellow perch (Pierce and Blood 1977), although no such behaviour was considered to occur in 1987. These creeks also support populations of white sucker, fathead minnow and sand shiner **(Notropis stramineus)** (Pierce and Blood 1977).

Long Creek is a relatively small stream which supports yellow perch, white sucker, fathead minnows and brook stickleback. Boundary Reservoir has been created near the confluence of Long Creek and the Souris River, and represents one of the largest waterbodies in the Souris Basin in Saskatchewan. This reservoir is stocked with walleye and largemouth bass **(Micropterus salmoides)** (Fisheries Branch stocking records). Yellow perch, bullheads and white sucker are reported as numerous in Boundary Reservoir; northern pike are present in low numbers although many pike were stocked in this waterbody in the early 1960's (Pierce and Blood 1977).

Moose Mountain Creek is the remaining significant tributary which enters the Souris River in Saskatchewan. This watercourse arises north of Moose Mountain Lake, and generally runs through a wide valley to its confluence with the Souris River near Oxbow. The northern half of the creek is characterized by a wide marsh in the valley bottom, with the creek forming a channel which runs through the centre of the valley. Numerous springs are present in upstream reaches of the drainage, which provides some of the clearest water in the basin. The creek substrate in this region has been reported to consist of sand or gravel (Pierce and Blood 1977). The creek itself is generally 1.5 to 2.5 m deep in the upper reaches. The fish fauna noted in the upstream areas of the creek consists of northern pike, yellow perch, fathead minnows and brook stickleback (Pierce and Blood 1977).

Moose Mountain Lake is situated in the upper reaches of the creek. This waterbody is relatively large (525 ha), and shallow (maximum depth of 4.3 m, mean depth of 2.2 m). The shoreline is steep, and slumping has occurred at several locations. Emergent vegetation is restricted to a few small bays on the lake. The shallow nature of the lake can result in critically low oxygen levels during the winter months. Northern pike and yellow perch have been stocked in the waterbody while a large population of white sucker is also present (Pierce and Blood 1977). Nutrient levels are relatively high in Moose Mountain Lake, and significant algae blooms occur in this waterbody during the summer months (Wallin 1980).

The downstream half of Moose Mountain Creek, from Carlyle to Oxbow, exhibits a silt substrate in pool areas, and cobble/bounder substrate in riffle areas. Gravel bars are relatively common. The downstream areas of the stream are characterized by long deep pools which are connected by short riffle sections. Near Oxbow, the channel tends to become deeper and wider, and the creek banks are heavily wooded. The creek valley is flat, and the valley walls are relatively steep. The fish fauna reported from the downstream reaches of the creek includes northern pike, yellow perch, white sucker, fathead minnow, common shiner, sand shiner, trout-perch, johnny darters and blackside darters (Pierce and Blood 1977), as well as ninespine stickleback **(Pungitius pungitius)** and bullheads (Wallin 1980). In addition, pearl dace

(Semotilus margarita) and Iowa darter have been recorded from Moose Mountain Creek (Atton and Merkowsky 1983). Extensive sampling during the spring of 1987 resulted in the confirmation of all species except yellow perch, sand shiner, trout-perch, blackside darters, ninespine stickleback and pearl dace. Brook stickleback, which had not previously been reported from Moose Mountain Creek, were found to be extremely abundant in this watercourse.

1.3 Fish Spawning Habitat

Spawning habitats for northern pike and yellow perch were evaluated as existing throughout the Souris River Basin during previous studies, although the success rate for pike spawning was considered to be quite low (Pierce and Blood 1977). This observation was, in general, confirmed during the spring 1987 investigation, although the lack of northern pike and yellow perch populations rendered this habitat unused. Walleye appeared to use some flooded fields upstream of Estevan for spawning, but major natural spawning areas for this species are apparently limited to the Souris River itself (Pierce and Blood 1977). Investigations conducted in 1987 did not confirm this conclusion, as no suitable walleye spawning habitat was apparent in flooded fields, or regions above these fields. Suitable walleye spawning habitat upstream of Estevan was noted only at the overflow channel at Midale Dam; the extent of this habitat was so limited that it would be incapable of supporting more than a very few (judged to be less than 50) walleye spawners. The conclusion reached during the previous study may have been the result of facilitated access for this species due to high river flows, and possibly the capture of this species in flooded fields as individual fish attempted to find suitable (but apparently non-existent) spawning areas.

Known or likely spawning areas for northern pike and yellow perch in the basin include the upper reaches of the Souris River near Cedoux and Colfax, the flooded marshlands below Nickle Lake Dam, both Jewel and Roughbark creeks,

and Moose Mountain Lake, as well as Moose Mountain Creek in the vicinity of the lake (Pierce and Blood 1977). The Souris River Valley west of Estevan and upstream to McDonald Lake was reported to be used for spawning by northern pike (Pierce and Blood 1977), although no such activity occurred in 1987. Bullheads spawn over a mud or sand bottom near vegetation (Scott and Crossman 1973), a habitat which is abundant throughout the Souris River Basin in Saskatchewan. Spawning habitat for the common forage fish species is also abundant throughout this area (Pierce and Blood 1977).

1.4 Growth Rate of Fish

As expected, the growth rates of the sport fish in the Souris Basin are greater than those recorded for northern Precambrian Shield lakes because the warmer temperatures, longer growing season and more productive southern basins facilitate faster growth (Pierce and Blood 1977). However, with the exception of the walleye population in the relatively stable Boundary Reservoir, growth rates of the important sport fishes in the Souris Basin are slower than those of the Qu'Appelle system. Likely causes for the slower growth rates in the Souris Basin are the significant fluctuations in water levels in the drainage, and the occasional severe shortage of water in the basin which should result in not only interrupted growth but very likely in almost complete mortality. The poor quality of Souris Basin water (in comparison to the Qu'Appelle system) in terms of temperature, turbidity and dissolved oxygen levels during the winter months likely also plays a role in limiting growth rates, as may the overwhelming population of rough fish in the basin (in particular black bullheads) (Pierce and Blood 1977).

1.5 Sport Fisheries

Angler use of the Souris River Basin in Saskatchewan varies extensively from one locale to the next (Blood and Associates 1977). These authors noted that over 60 percent of the anglers that fished the Souris River

originated within an 80 km radius of the river, indicating that the sport fishery is carried out mainly by local people. Walleye are the preferred species in the basin, although yellow perch are the dominant species taken. Major angling areas on the Souris River in the spring are Nickle Lake Regional Park, the Souris River between Dr. Mainprize Regional Park and the south end of Dead Lake; ice fishing is concentrated at Nickle Lake, Dr. Mainprize Regional Park and Dead Lake (Souris Basin Development Authority, Background Report). Moose Mountain Lake is a popular angling lake for local people; ice fishing also takes place on this waterbody (Wallin 1984).

The region as a whole receives high angling pressure, particularly in Moose Mountain Provincial Park which is the most popular provincial park in Saskatchewan. Prier (1980) noted that the park received over 500,000 visitors per year. A 1980 survey of sport fishing in Saskatchewan profiled angler activity in the region (Murray **et al.** 1984). The survey found that 80 percent of the provincial sport fishing activity carried out by Saskatchewan residents occurs in the southern half of the Province. Within the southern region, 87 percent of the anglers are residents and 91 percent of the effort in this area is by residents. Walleye, northern pike and yellow perch are the preferred species, while pike and perch comprise 91 percent of the catch even though residents show a clear preference for walleye. The survey revealed that residents were very critical of fishing quality and the level of service provided to sport fishermen. Non-residents gave far higher ratings for the quality of fishing and service than did the residents, but most of the non-residents fished in the north. In 1980, 3 million dollars were spent on sport fishing in the southern region, but this was only 9 percent of the total money spent on sportfishing in the Province of Saskatchewan.

The existing demand for sport fishing in the southern region of Saskatchewan exceeds the supply of fish (Murray **et al.** 1984).

PHOTO ONE: Oxbow weir on Souris River effectively blocks fish movements during low flows. April, 1987.
(Photo courtesy Environmental Management Associates)

PHOTO TWO: CPR weir on Souris River in Woodlawn Regional Park, Estevan. April, 1987. Weir serves as walkway between swimming pool, north of river and campground on south side.
(Photo courtesy Environmental Management Associates)

PHOTO THREE: Spring runoff - upper Moose Mountain Creek. April, 1987.
Note aspen groves and cultivated fields in background.
(Photo courtesy Environmental Management Associates)

PHOTO FOUR: Fisheries studies, Moose Mountain Creek. April, 1987.
(Photo courtesy Environmental Management Associates)

PHOTO FIVE: Electrofishing in Moose Mountain Creek. April, 1987. (Photo courtesy Environmental Management Associates)

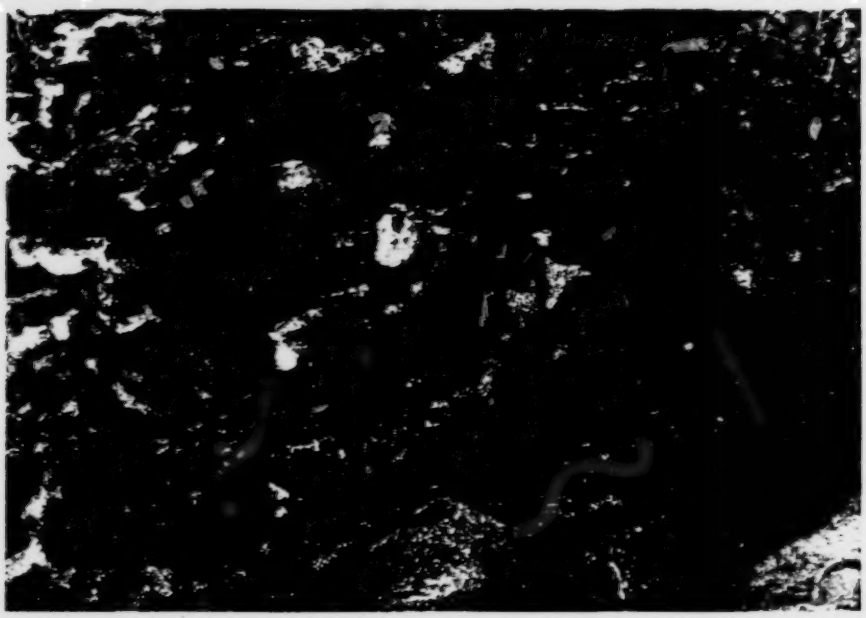


PHOTO SIX: White suckers, attempting to ascend the dam at Oxbow. April, 1987. (Photo courtesy Environmental Management Associates)

2.0 PREDICTION OF IMPACT

2.1 Introduction

The following section of this report discusses the implications of constructing the Rafferty Reservoir to the Souris River fishery resource. This analysis considers the consequences of an impoundment extending from the region of McDonald Lake upstream to the region above the confluence of Roughbark Creek and the Souris River. It is recognized that the potential effects of constructing and operating the Rafferty Reservoir cannot be completely addressed without consideration of the proposed Alameda Reservoir on Moose Mountain Creek, particularly in the context of cumulative impacts on the aquatic resources of the Souris River Basin in Saskatchewan. Baseline data collection for the Alameda Reservoir is currently underway, and consideration of cumulative impacts cannot be totally addressed until the appropriate data are available. The Impact Statement Supplement prepared for the Alameda Reservoir will therefore include consideration of cumulative impacts of both projects.

The construction and operation of the Rafferty (and Alameda) Reservoir is perceived by the public and regulatory agencies as providing exceptional opportunities for fisheries development in southeastern Saskatchewan. Following is a discussion of potential impacts on the fisheries resource during the construction and operational phases of the Rafferty project. Emphasis during this discussion is placed upon existing and potential sport-fish populations in this region of the Souris Basin in Saskatchewan.

2.2 Potential Impact During Construction Activities

During construction of the dam, ancillary facilities, and access roads, a number of impacts on the fisheries resource may result.

2.2.1 Blockage of Fish Movements

Construction activities in the mainstem river channel during the spring period may create physical or velocity barriers sufficient to block the upstream movement of spawners, as well as other life stages moving upriver for

the summer months. Such movements would likely occur only if high water levels prevail during the construction period. Blockage of potential movements could result in the loss of aquatic habitats along a 30 km segment of the river during the construction phase.

2.2.2 Loss of Fish Habitats

Northern pike and yellow perch spawning habitats are presently relatively abundant downstream of the proposed reservoir. These habitats will be lost with the channelization which will be required between the damsite and Estevan. The very limited walleye spawning habitat which exists at the Midale Dam will also be lost as will northern pike and yellow perch spawning habitat between Dead Lake and the Rafferty damsite. Use of this habitat at present appears to be restricted to high water years.

Loss of this riverine habitat for the summer months to the migratory species in the river would not likely result in fish mortality but growth rates for this time period may be reduced if alternative, unoccupied summer habitat is not available downstream of the damsite. Downstream habitat was essentially unoccupied during the spring of 1987, as standing crops of fish were very low.

2.2.3 Sedimentation

Construction activities associated with the dam, ancillary facilities and access roads will result in increased suspended sediment concentrations and subsequent deposition downstream of the construction site. The direct and indirect effects of sedimentation have been well documented and reviewed by a number of authors including Cordone and Kelley (1961), Phillips (1971) and Griffiths and Walton (1978). Increased sedimentation effects should be relatively short-term (i.e., during site construction and stabilization), but could reduce the survival of any eggs spawned below the construction site. However, the Souris River within the Study Area is currently subject to relatively heavy suspended sediment levels, particularly in the spring, and the fish fauna has apparently adapted to this Basin characteristic. Therefore, impacts from short-term sedimentation are considered to be relatively minor in nature.

2.2.4 Toxic Materials

Disposal or accidental spillage of materials such as oil, gasoline, drilling fluids or other chemicals during the construction phase could adversely affect fish. The severity of any impacts resulting from any such occurrence would depend on the type of material and amount entering the river. The proponent's commitment to effective precautionary measures for the storage and handling of any such materials will greatly reduce the probability of any such occurrences.

2.2.5 Sport-fish Harvest

Resource harvesting activities may be affected during the construction phase of the project in very localized areas, notably downstream of Dead Lake, if dam construction precludes fish access to the region of the river between Dead Lake and the Rafferty damsite. Such an occurrence would presumably result in a relocation of fishing activities, upstream to Dead Lake, which is evaluated as a minor inconvenience to the very few anglers involved.

2.3 Potential Impact During Operation and Maintenance

The construction of a dam transforms the terrestrial and riverine ecosystems in the affected area into a lacustrine (lake) ecosystem, or into a slower-moving riverine ecosystem in the case of some run-of-the-river reservoirs. This results in physical, chemical and biological changes in the aquatic environment as the reservoir develops and stabilizes. Due to the complexity of interactions that occur in a newly formed reservoir, prediction of the effects of the development on the aquatic resource may not be made with a high degree of certainty.

Major impacts on the aquatic resource that would occur during the operational phase of Rafferty Reservoir would likely be related to:

a) the blockage of fish movements, the inundation of riverine habitat and the resultant characteristics of the reservoir thus created; and

b) the effects of an altered flow regime downstream of the reservoir.

2.3.1 Fish Movements

The proposed dam on the Souris River will block spring spawning movements of fish, as well as the seasonal movements of the remaining fauna into the segment of the river between the damsite and Dead Lake. These movements apparently occur during high-flow years. This will have a negative impact on the fish populations in the Souris River downstream of the damsite, the extent of which will depend on the operational regime of the reservoir and mitigative measures incorporated into project planning for downstream areas of the river. These concerns are addressed later in this document.

2.3.2 Fish Habitat

Reservoir creation will result in the inundation of approximately 64 km of riverine habitat, as well as the Dead Lake Reservoir and several kilometres of the lower reach of Roughbark Creek. The significance of this riverine habitat loss may be addressed on the basis of both present fish use and anticipated reservoir habitat suitability. In this context, the only important fish habitat which will be lost to Souris River mainstem fish populations will be that which exists in the river segment between the Rafferty damsite and Dead Lake, as discussed above. Dead Lake, which primarily provides northern pike and yellow perch habitat as well as marginal walleye habitat, will be replaced by the larger Rafferty Reservoir. The river reaches upstream of Midale Dam, which are primarily used for northern pike and yellow perch spawning, as well as summer use by other life stages of these species during high-flow years, will also be lost during reservoir creation. Of these upstream losses, only that of

northern pike spawning habitat is considered critical, depending primarily on the operating regime of the reservoir. With the creation of an impoundment, reproduction by northern pike is typically highly successful, as a result of the inundation of adjacent lands and thus the abundance of flooded vegetation which may be used as spawning substrate. However, once operational levels in the reservoir are reached, northern pike reproduction becomes dependent on the operating regime (Machniak 1975a).

It is a well-documented fact that during the second stage of reservoir existence (i.e., the stabilization stage), spawning conditions for northern pike become gradually poorer, due to the deterioration of emergent vegetation, and stabilization of water levels which eliminates annual flooding and hence flooded vegetation. Northern pike reproduction may still be successful, provided that water level regulation closely follows the natural situation. If water levels are rising (i.e., flood vegetation) and are maintained at a high level during the spring, northern pike spawning is generally highly successful (Machniak 1975a). Conversely, if water levels are low, or are dropping in the spring, pike reproduction is generally poor.

As the water levels may be low in the spring, and the extent of reservoir filling will be highly dependent on available spring runoff from year to year, a mitigation measure which will be incorporated into project design is the creation of wetland areas at the upper end of the reservoir. Water levels in these wetlands will be maintained by low-level weirs. Fish passage facilities will be incorporated into weir design to facilitate access for spawners moving upstream from the reservoir. This mitigation measure will not likely compensate for the total loss of northern pike spawning habitat which is inundated by Rafferty Reservoir. However, the permanence of these wetlands and therefore their availability for spawning use on an annual basis is considered to be a considerable improvement over the existing conditions. Spawning success is currently variable due to the degree of flooding, or lack thereof, which is experienced in this region of the basin.

Summer-use riverine habitats will also be lost in the upstream areas of the reservoir. As these habitats will be replaced by the reservoir environment and all species under discussion are well-adapted to such environments, the creation of the reservoir would result in a greater availability of habitat for use by these life stages. Some riverine habitat will also continue to be available for any obligate riverine species originating in the reservoir, contingent upon releases from Nickle Lake.

2.3.3 Water Quality

The potential water quality of the Rafferty Reservoir is discussed in the Water Quality section of this Environmental Impact Statement. The modelling which was carried out indicated that the impoundment would likely be very productive (eutrophic), with relatively high conductivity (600 usie/cm), and a relatively high pH (range of 8.5 to 9.5). Due to the productive nature of the reservoir, blue-green algal blooms may occur in mid to late summer, which, if present in sufficient quantities, are aesthetically unpleasant and in severe cases result in oxygen depletion of the waterbody during the late summer. Due to the relatively shallow nature of the impoundment (average depth estimated at 8.9 m), the reservoir should not permanently stratify, but may stratify intermittently. As a result, bottom water dissolved oxygen concentrations may decline to low levels, but these oxygen deficits should be replenished when wind activity causes lake circulation. This should alleviate concerns regarding critically low dissolved oxygen levels in regard to the well-being of the fish resource during the open-water season. The lack of permanent thermal stratifiction does, however, indicate that the reservoir will experience relatively high water temperatures during the summer months, which may restrict the fish fauna to tolerant coolwater and warmwater species.

During the winter months, when ice cover precludes atmospheric reaeration, oxygen depletion in prairie lakes and reservoirs may become severe. The results of empirical water quality models reveal that oxygen depletion in the Rafferty Reservoir should not occur if the impoundment is at or near Full Supply Level at freeze-up, as dissolved oxygen concentrations should be in the range of 5 mg/l. However, at low water levels the empirical models predict

dissolved oxygen concentrations as low as 0 mg/l as possible. There is also potential for high ammonia concentrations during such periods of low oxygen. High levels of ammonia are toxic to fish. It is felt that there is risk that Rafferty Reservoir may go anoxic under low water conditions in the late winter. This would likely result in the loss of desirable sport-fish species, if such a condition arose without the incorporation of any mitigative measures. Mitigative options under consideration for the project, pending further investigation into the likelihood of anoxic winter conditions, include lake aeration, nutrient inactivation, or snow clearing during the winter months to promote photosynthesis and thus natural reoxygenation. The reservoirs will also be cleared of as much organic material as is practicable prior to filling, to minimize the initial organic load in the impoundment as well as eliminate potential hazards to boaters and fishermen.

The relatively high pH (8.5 to 9.5 range) which is anticipated for the waterbody is an additional concern in relation to the well-being of the fishery resource, as the generally accepted range for suitable fish habitat is 6.5 to 9.0. Although the pH range itself is not lethal for most fully developed freshwater fish, it may affect the toxicity of other cations and anions in the environment (Katz **et al.** 1979).

2.3.4. Biological Productivity

The biological productivity of a reservoir is the result of the interaction of a large number of complex biotic and abiotic factors. Some of the more obvious interacting components include edaphic factors (Rawson 1939; Sparrow 1966), the type and distribution of organic material in the basin (Edmondson 1957), the morphometry of the basin (Rawson 1952; Ryder 1965), nutrient influx from upstream areas (Hynes 1970), climatic factors (Rawson 1942; Talling 1966; Brylnsky and Mann 1973), turbidity and the depth of light penetration (Murphy 1962), hydraulic retention time (Nursall 1952; Taylor 1971), and the biological species present. Due to the complexity of the interactions which may occur within the system, it is difficult to predict, with certainty, the biological characteristics of the future reservoir. However, some general trends can be predicted based on available data and the characteristics of the proposed reservoir site.

It is well known that the shallow, nearshore regions (littoral areas) are highly productive in aquatic ecosystems (Reid 1961; Wetzel 1975). This littoral zone, defined by Rutner (1963) as "that portion of the shoreward profile inhabited by autotrophic plants and sessile algae", is normally very important for fish production. Zoobenthos, a major food source for fish, generally are more abundant in shallow waters where aquatic plants are present. Aquatic macrophytes often provide nursery and rearing habitat for juvenile fish and cover for adult fish. Also, numerous fish species (especially cyprinids) utilize vegetation for spawning.

The morphometry of the Rafferty Reservoir would provide a relatively extensive littoral zone, particularly at the upper reaches of the reservoir. The anticipated operating regime is, however, expected to restrict the development of aquatic macrophytes in the littoral zone of the reservoir. In average years the water levels will begin to decline in the fall, with this process continuing until reaching a yearly minimum during the spring period. After reaching a minimum, levels generally increase sharply over the next two months. This lowering of the water levels in the Rafferty Reservoir would expose considerable surface area and would subject aquatic plants that have developed in this region to dessication and/or freezing. This environment likely would severely restrict the development of aquatic vegetation communities in the reservoir. Reid (1961) noted that reservoirs with fluctuating water levels generally have little rooted aquatic vegetation. Cooke (1980) noted that drawdown can be used to control rooted aquatic macrophytes when there is nearly complete dewatering of the sediments and a sufficient (one month or more) period of cold (freezing) or heat. However, limited growth of some of the more tolerant species may occur within or below the drawdown zone.

When a reservoir is first created, nutrients leaching from the soils, flooded vegetation, and organic detritus usually increase nutrient levels in the water which, in turn, facilitates increased phytoplankton and benthic algae production (Funk and Gaufin 1971; Zhadin and Gerd 1973). This pattern will likely be exhibited in the Rafferty Reservoir, and as previously discussed, will contribute to extensive phytoplankton (notably blue-green algal blooms in late summer) and zooplankton production in the reservoir. In terms of zoobenthos,

impoundment of the Souris River would result in a general shift from riverine benthic fauna (i.e., insects such as stoneflies) to lake-type fauna (i.e., oligochaetes and chironomids) in the parts of the river which are currently flowing. This transition and colonization of newly flooded areas will probably occur rapidly; however, development of permanent stable populations of species adapted to the specific reservoir conditions may take up to 10 years (Lyakov 1973).

Water level fluctuations in the Rafferty Reservoir will likely restrict the development of zoobenthos. In natural lakes the maximum densities of benthic invertebrates occur in the shallow water areas. Grimas (1961) recorded a loss of 70 percent of the bottom fauna in the regulated zone in Lake Blasjon, Sweden. The timing of the drawdown in Rafferty Reservoir may also have a detrimental effect on zoobenthos within the drawdown areas. Paterson and Fernando (1969; 1970), and Benson and Hudson (1975) reported that freezing of the exposed substrate during drawdown (as would occur during the winter months) resulted in high mortality of the benthic invertebrates buried within the substrate. Some recolonization of the drawdown area by benthos would occur during filling periods. Paterson and Fernando (1969) noted a rapid dispersal of chironomids into the drawdown zone after reflooding of the previously exposed substrate. Other motile species such as mayflies and caddisflies may also colonize the drawdown area after reflooding; however, the littoral benthic fauna is expected to remain sparse. This will limit the value of shoreline areas of the reservoir as rearing or feeding habitat for fish.

2.3.5 Fish Populations

As prevously noted, impoundment of a river to form a lentic system generally leads to an increase in nutrients in the water due to leaching from flooded vegetation and soils. The Rafferty Reservoir will also have relatively high nutrient (nitrogen and phosphorus) inputs. These nutrients are quickly assimilated by the phytoplankton, which leads to increased zooplankton populations. The greater availability of fish food organisms results in higher fish production; however, the initial high fish production rate generally declines to a long-term sustainable level that is approximately one-half of the

peak level recorded. Reservoirs typically exhibit a lower fish species diversity than occurred naturally; in addition, species composition often shifts from an initial assemblage dominated by piscivorous sport fish species, towards one composed of a higher proportion of coarse fish species.

Fish habitat availability and suitability will be strongly influenced by the drawdown regime. Water level fluctuations and drawdown minimums have been identified as one of the most important factors limiting fish production in reservoirs (Fraser 1972). In view of predicted water level fluctuations and existing terrain features, suitable littoral areas for spawning, rearing and feeding are likely to be in short supply in the reservoir. Shallow coves and bays are limited, with the reservoir displaying a relatively low shoreline development factor. The extent of tributary habitat (for spawning/rearing) will be limited primarily to Jewel and Roughbark creeks. The remaining tributaries are intermittent. The Souris River above the proposed reservoir will provide only limited suitable habitat, primarily for obligate riverine species, between the upstream region of the reservoir and Nickle Lake.

Due to the complex interrelationships between biotic and abiotic factors in a newly formed reservoir, and the competition between and within species for the available habitat and food resources, it is not possible to make precise projections about species composition and relative abundance of the reservoir fishery. Because of the paucity of information regarding the responses of major fish species to impoundments in north-temperate areas, predictions are based primarily on knowledge of the environmental requirements of individual species, the probable abiotic and biotic conditions which would be present or develop in the reservoir, and professional judgements. These predictions are based on what would likely happen under postimpoundment conditions with no artificial manipulation (i.e., no stocking of the reservoir or fish habitat enhancement).

It is expected that the Rafferty Reservoir will support a species assemblage similar to that now present in the natural system. Species estimates for the reservoir have been prepared for two resident species, yellow perch and white sucker, as these were the only species for which the necessary information was available for the model employed in the analysis. Species presence and probable abundance can generally be assumed to be proportional to the

suitability of the reservoir habitat. Further values or production estimates have not been made because of uncertainties in the evaluation process (e.g., difficulty in forecasting species responses in a new reservoir). The discussion that follows has been limited to major species of interest.

Reservoir habitat suitability was modelled using the evaluation system described by McConnell **et al.** (1982). This system classifies proposed coolwater reservoirs into four categories of fish habitat suitability (low, low-medium, high-medium, and high) based on the physical configuration of the reservoir basin, site climate, operational requirements and inflow characteristics. Habitat suitability is determined on the basis of a composite score of five "primary" reservoir attributes (temperature, turbidity, nonliving cover, drawdown and shallow cover frequency). The value of each primary attribute is determined from one or more secondary attributes (growing season, mean depth, turbidity, etc.).

The secondary attributes used in developing the individual scores for primary attributes and the final reservoir descriptors are summarized in Table 1.

Habitat suitability was modelled for two representative lacustrine species (yellow perch and white sucker) found at the reservoir site (and for which descriptors were available in the publication by McConnell **et al.** 1982). Yellow perch, while found in a variety of lake types and habitats, have relatively specific spawning habitat requirements. White suckers on the other hand, are tolerant of a wide range of environmental conditions.

Rating scores and the suitability of the proposed Rafferty Reservoir are summarized in Table 2. A reservoir descriptor value of 32233 was calculated resulting in a low-medium (LM) habitat suitability for yellow perch and a high (H) suitability for white sucker.

Walleye may establish in the reservoir, although it is likely that very few will be trapped in the reservoir area at dam closure. The success of reproduction will depend on the suitability and availability of spawning sites. The pattern of walleye development in reservoirs is often the reverse of that observed in northern pike (Machniak 1975b). Initial flooding results in poor spawning success; however, as more coarse materials become exposed (i.e., wave

TABLE 1

SECONDARY ATTRIBUTES FOR RAFFERTY RESERVOIR MODEL

(Determination of values described in McConnell **et al.** 1982)

1.) Growing season
   - 80 - 120 day frost free period

2.) Mean July air temperature:
   - +18 to 21°C

3.) Storage ratio:
   - 12.57 year (mean)
   - based on a reservoir volume of 392 300 dam^3 and average annual regulated discharge of 0.99 m^3/s

4.) Depth of outlet in relation to mean depth:
   - midline depth of low level outlet = approximately 537.5 m el.
   - mean depth = 8.9 m
   - within lower one-third of mean depth

5.) Maximum fetch:
   - maximum uninterrupted distance = 57 km

6.) Mean depth:
   - 8.9 m

7.) Mineral turbidity:
   - reservoir expected to have Secchi values between 0.5 and 1 m after stabilization

8.) Extent of maximum drawdown:
   - Average 5 m

9.) Time of maximum drawdown:
   - Nov - Feb

10.) Shoreline development factor:

$$- D_L = \frac{L}{2\ 3.14A} = \frac{175\ km}{2\ 3.14 \times 45.5} = 14.6$$

where L = shoreline length in km

A = surface area in km^2

TABLE 2

MATRIX VALUES - COOLWATER SPECIES (white sucker and yellow perch)

A. Option II: Coolwater Species

a) Climate (growing season/mean July air temperature) = 3

b) Operation (mean storage ratio/depth of outlet relative to mean depth) = 1

c) Stratification score (mean depth/maximum depth) = 1

Primary temperature score (operation - stratification) = 3

B. Primary water quality score (mineral turbidity) = 2

C. Non/living cover Matrix 2

Option II - Cliffs and shoals (old river banks) = 2
(Linear extent of structure is deepest half of reservoir/linear extent of structure at full basin)

D. Drawdown extent

Primary drawdown extent and timing score (extent of maximum drawdown over 5 y/period of year) = 3

E. Shallow cover frequency

Primary shallow cover frequency score (mean depth/ shoreline development) = 3

Reservoir Descriptor = 32233

White Sucker = H habitat suitability

Yellow perch = LM habitat suitability

washing action along shore margins) walleye numbers increase (Erickson 1972). Water level fluctuations may affect the availability of suitable reservoir spawning sites and also incubation success. Walleye spawn in water less than two metres in depth in most reservoirs and also do best in impoundments with slow water-level fluctuations (Erickson 1972). Some suitable substrates may be provided by the rip-rap and armouring materials across the face of the dam and on the two Dead Lake closure dams and at causeway locations. Grinstead (1971) reported walleye spawning on the rip-rap face of the Canton dam in Oklahoma.

Overall, the suitability of the reservoir for walleye production is expected to be similar to its suitability for yellow perch (low-medium). Although these species have different spawning requirements, the abundance of walleye in several reservoirs has been correlated to the abundance of yellow perch (usually an important forage species for walleye; Maloney and Johnson 1957).

2.3.6 Mercury in Fish

Recent research has shown that bioaccumulation of natural mercury in the biota of new impoundments may occur in the early years of flooding (Abernathy and Cumbie 1977; Bodaly and Hecky 1979) such that mercury concentrations in fish exceed the Saskatchewan guidelines established in 1986. The possibility therefore exists that mercury concentrations in fish in the Rafferty Reservoir will increase over present concentrations, possibly exceeding the guideline and impairing the reservoir fishery. Current Saskatchewan Parks, Recreation and Culture guidelines indicate that human consumption of fish is not recommended when mercury levels are greater than 1.5 parts per million (ppm). The Saskatchewan guidelines for consuming fish containing mercury indicates that fish with an average mercury concentration of less than 0.5 ppm may be eaten in unlimited amounts. There are two categories for limited consumption:

1) Fish containing 0.5 to 1.0 ppm mercury: not more than 10 meals for one week or 1 meal/week on a long term consumption basis; and
2) Fish containing 1.0 to 1.5 ppm mercury: not more than 7 meals for one week or 1 meal every 2 weeks over long term.

On the basis of studies reviewed by Noton (1981), it appears that new impoundments may experience enhanced bioaccumulation of natural mercury in fish. Bodaly and Hecky (1982) have concluded that any reservoir in cool-temperate North America is likely to experience predatory fish mercury concentrations in excess of 0.5 ppm. New impoundments in northern Manitoba have experienced mean mercury concentrations of 0.6 - 2.3 ppm in pike, and 0.8 - 2.9 ppm in walleye (Bodaly **et al.** 1984), and a new impoundment in southern Saskatchewan contained walleye with a mean concentration of 1.04 ppm (Waite **et al.** 1980). The phenomenon seems to be a result of bio-mobilization of natural mercury in the flooded terrain. The populations of predatory fish which develop in the Rafferty Reservoir may have a mercury content which exceeds 0.5 ppm, but based on the results presented by Waite **et al.** (1980) for the Cookson Reservoir, these fish should be safe for limited human consumption. Other fish species such as suckers are likely to have lower mercury concentrations because of their lower position in the food chain. Fish in the Souris River downstream of the reservoir may also acquire higher mercury concentrations. The duration of this phenomenon is difficult to estimate: some earlier work (reviewed by Noton 1981) suggested that it would abate after a few years but work on the Churchill River diversion impoundments in northern Manitoba (Bodaly **et al.** 1984) has found no decline from peak concentrations within 5-8 years of impoundment. That work also indicated that the amount of mercury increase was positively related to the amount of new area flooded in the impoundment.

The potential for mitigating any increase in fish mercury is limited and of uncertain effectiveness, however the Authority will develop a monitoring program to measure mercury levels in fish following impoundment.

2.3.7 Downstream Water Regime and Habitat

Placement of a dam on the Souris River will result in alteration of existing downstream flow regime and fish habitat conditions in the mainstem river. Both immediate and delayed changes will be experienced, although present information on the nature of these changes is limited. Consequently, predictions of effects on downstream fish populations are difficult.

The effects of an altered flow regime may have both positive and negative impacts on fish populations. Determining specific impacts resulting from flow alteration requires site-specific information on habitat utilization by the fish fauna, and knowledge of daily flow fluctuations. At this stage in project development, only the general effects of altered flow regimes can be considered.

At the present level of project planning, it is anticipated that releases from the reservoir will follow a pattern generally similar to the present hydrograph, but with an attenuation of peak flows and an augmentation during very low-flow periods. The basic function of the reservoir is to provide flood control, recreational opportunities and a supply of industrial and downstream irrigation water; therefore, sufficient water has to be stored to meet these requirements, plus any downstream riparian needs.

Under regulated flows, seasonal flow fluctuations below the dam will be reduced. Flows should be relatively stable on a weekly basis. Riverine fish populations are, by necessity, very facultative in terms of their ability to adapt to seasonal flow changes and these particular alterations are not expected to be a major concern for most downstream fish populations.

Project planning to date has incorporated channelization and stabilization of the river between the damsite and Estevan into project design. This will likely result in the loss of the existing fish habitat in this reach of the river. A very small population of fish are resident in this region of the river, due to the blockages to fish movement at the weir south of Estevan. The mainstem Souris River downstream from the damsite is presently characterized by a low habitat diversity, a result of the uniform substrate (primarily silt), and a lack of riffle/run/pool complexes.

Reduction in flows during freshets may reduce scour in the system and also may result in the deposition of fines in the relatively infrequent riffles and pools in the lower reaches of the river. This, in addition to the stabilization of base flows, could promote an increase in already extensive macrophyte colonization of the river. Northern pike spawning habitat may increase if this occurs; however, a reduction in pool depths resulting from increased sedimentation would reduce the amount of rearing and feeding habitat. Sedimentation of riffles would also reduce the already limited spawning habitat for walleye.

The sediment-free discharges at the damsite are not expected to have major impacts on the fish fauna, although increased clarity could enhance development of macrophytes, which may increase potential spawning habitat for northern pike. Benthic productivity may be increased, providing an increased food supply for forage species, which in turn may influence the feeding success of piscivorous species such as northern pike. However, species with a preference for turbid riverine environments (i.e., walleye) could be further limited in their occurrence and use of the Souris River in Saskatchewan.

Riverine fish populations are adapted to defined daily, seasonal, and yearly temperature regimes (Allen 1969, Hubbs 1972 in Ward and Stanford 1979). Alteration of existing temperature regimes below a reservoir can directly, or in a synergistic manner with other changes (e.g., altered seasonal patterns), reduce the suitability of a reach for a given species or species life requisite (e.g., spawning). However, a change in the thermal regime of the Souris River may not occur due to the lack of permanent thermal stratification of Rafferty Reservoir; therefore, alterations to the thermal regime of the river are not anticipated to be a concern.

In regard to the potential effects of the quality of the water released to the Souris River downstream of the dam on the fishery resource, the results of water quality modelling indicate that an improvement over existing conditions is likely. The only potential concern identified to date is the possibility of occasional releases of de-oxygenated waters from the reservoir during periods of intermittent stratification in the summer, and the potential for release of anoxic water during the late winter.

Downstream conditions subsequent to reservoir formation indicate a loss of habitat between the dam site and Estevan. Riverine conditions downstream of Estevan will likely be an improvement over the existing environment, due to security of flow and improved water quality conditions. The potential for alterations in fish habitat availability downstream of the Rafferty Reservoir, including the potential impact of the proposed future rock weirs to augment irrigation water withdrawals, are being considered as a component of the Alameda project, and will be fully addressed as a component of the ongoing 1987 work. This information will be provided to Saskatchewan Environment when it becomes available.

3.0 RECOMMENDATIONS

3.1 Introduction

The creation of the Rafferty Reservoir has the potential to provide significantly improved water-based recreational opportunities for the southeastern region of the Province. Potential limitations to the development of a high-quality fishery resource in the Rafferty Reservoir have been described in the previous analysis of impacts. As there is a firm commitment by the Souris Basin Development Authority for development of the fishery resource, mitigative options and enhancement opportunities will be undertaken and these are discussed, relative to the impacts they address, in the following sections.

3.2 Mitigation and Enhancement

3.2.1 Pre-construction and Construction Activities

The potential impacts identified in regard to reservoir construction activities involved the blockage of fish movements at the damsite, and therefore the potential loss of upstream spawning and rearing areas during the construction period, as well as the potential loss of angling opportunities from this segment of the river. To the extent practicable, efforts will be made to provide migration routes for the fish fauna during the construction phase (e.g. diversion route), in an effort to mitigate this potential impact. This habitat will, of course, be lost to the Souris River fishery once the dam is completed.

The potential for the introduction of sediment during construction will be minimized during the construction phase. Efforts will be made to conduct instream construction activities during low-flow periods. A code of good construction practice will be followed to minimize the risk of introducing any toxic materials to the watercourse during the construction phase.

3.2.2 Operation and Maintenance

Fish Habitat

A loss of spawning habitats will occur along both the riverine and lake environments which will be inundated by the reservoir, particularly those presently used by northern pike and yellow perch. As previously described, permanent wetland areas will be created in the upper reaches of the reservoir, to which northern pike will have access for spawning. Efforts will also be made to establish vegetation within the drawdown zone, which may be used by both northern pike and yellow perch for spawning and rearing purposes.

Walleye spawning habitat, which is presently very limited within the reservoir area, will likely be created along the edges of the reservoir. Wave action will scour fine materials from the walls of the reservoir, to create suitable cobble/boulder spawning substrate. Additionally, the rip-rap faces of the dam itself, the Dead Lake channel (upstream) closure dams and the causeways will provide some spawning habitat for this species. Where gravel is removed below Full Supply Level, the resulting pits will be terraced and supplemented with boulders to provide additional walleye spawning habitat.

Sport-Fishing

A major thrust of the mitigation program for Rafferty Reservoir will be the creation of a sport fishery. The physical habitat of the reservoir, as well as the anticipated temperature regime and water quality characteristics will be critically evaluated, and, in consultation with Saskatchewan Parks, Recreation and Culture, the most suitable sport species for introduction will be determined and a long term Fisheries Management Plan will be prepared. Species to be considered for the reservoir include rainbow trout, largemouth bass, smallmouth bass and walleye. The physical habitat requirements of the species identified for the enhancement program will be evaluated in conjunction with anticipated habitat availability of the reservoir, and where these requirements are not met, they will be created during the construction phase of the project. Such enhancement activities may include the creation of cover, rearing ponds, and possibly artificial spawning reefs in appropriate locations. Operational practices will also be considered in this analysis, such as the feasibility of

placing operational priorities on the protection of a particular life stage (e.g., spawning or overwintering). In addition to establishing the fishery resource itself, the Souris Basin Development Authority will also ensure access to the fishery is provided, in the form of access roads, boat-launch ramps, piers and wharfs, including suitable facilities for the physically disabled.

Water Quality

The relatively high productivity of the reservoir may result in blue-green algal blooms and the de-oxygenation of reservoir and downstream river waters. The feasibility of reducing nutrient inputs to the reservoir will be examined, and any practical alternatives in this context will be pursued. The benefits of selective reservoir clearing (to provide habitat in the form of cover) have been evaluated in conjunction with the disadvantages of the organic loading which would occur if as much organic matter as possible was not removed from the reservoir prior to filling. The result of this analysis was that the latter option (reservoir clearing) will be pursued to minimize initial organic loading of the reservoir. If it is determined that necessary cover is lacking for the sport species to be managed in the reservoir, cover will be created through activities such as reservoir contouring, selective placement of brush shelters or the creation of artificial reefs. As previously described, physical characteristics such as littoral cover will be included in reservoir design following identification of the most suitable sport species for the reservoir, and the habitat requirements for this fauna in relation to that which will be available in the reservoir.

In reference to the potential for low dissolved oxygen levels in the summer months during periods of intermittent stratification, or extensive algal blooms, several options will be evaluated by the Authority. The feasibility and practicality of nutrient inactivation in the reservoir will be evaluated, and pursued if possible. The practicality of back-flooding and harvesting of forage crops (e.g., hay) or upstream marsh vegetation (e.g., cattails, bulrushes) will be examined in terms of potential effects on nutrient removal. Specific options to be examined for feasibility and practicality are the aeration of reservoir waters through active (e.g., compressors when

required) or passive (e.g., windmill pumps) means. Aeration of reservoir discharges will also be accomplished through spillway design features; an example of an option being considered in this context is a hydraulic jump and stilling basin at the reservoir outlet. Another alternative which is being evaluated for mitigating potential low oxygen conditions during the winter months is snow clearing, to facilitate light penetration and oxygenation through the photosynthetic activity of phytoplankton. In the event that anoxic conditions cannot be avoided in the reservoir, the necessary stocking requirements for maintenance of a sport fishery will be undertaken, as will requirements for rearing facilities. Any such rearing ponds will be located in areas of maximum public accessibility to maximize tourism and recreation benefits through interpretation.

Downstream Habitat

The potential impacts of reservoir creation and operation on the fishery resource of the downstream Souris River include the consequences of an altered flow regime, altered physical and chemical characteristics of reservoir releases, and alterations to downstream channel morphology. Significant gains in the quality of the fishery resource in the Souris River may also be realized through a consideration of this habitat in reservoir planning. The potential for habitat protection and enhancement of the Souris River will be examined in detail during studies which are presently underway for the proposed Alameda Reservoir. Likely impacts include the loss of habitat between the damsite and Estevan where channelization is required, and a significant improvement in habitat downstream of Estevan where improved water quantity and quality conditions (over existing) should prevail. Where low level weirs are required downstream for irrigation purposes, (current estimates are for as many as twelve), provisions in their design will be made to facilitate fish passage.

3.3 Monitoring

3.3.1 Pre-construction and Construction Activities

The requirements for fisheries monitoring during pre-construction and construction activities are minimal. Monitoring programs during this stage of

the project include surveillance of construction activities to ensure maintenance of appropriate water quality standards and compliance with the code of good construction practices established for the project. Fish passage facilities at the damsite will be monitored during construction to ensure movements are facilitated where possible. If dam closure occurs when fish are thought to be present between the damsite and Dead Lake (an area subject to summerkill or winterkill), consideration will be given to capture and transport of sport species if significant numbers of fish are present. Samples of fish will also be taken during this stage of the project to document mercury levels prior to reservoir filling.

3.3.2 Operation and Maintenance

Monitoring activities during reservoir operation will involve periodic examination of water quality characteristics in the reservoir to evaluate suitability for the sport species being managed in the reservoir. Periodic fishery sampling will also be conducted to evaluate fishery productivity in the waterbody, and the effectiveness of mitigatory measures incorporated into reservoir design and operation. The results of this monitoring program will be employed to determine if alterations to enhancement structures or techniques, or to the operating regime are required to realize the full potential of the fishery in the Rafferty Reservoir.

Mercury levels in fish flesh will also be determined at regular intervals, such as post impoundment years 1, 3, 5 and 7, to determine the suitability for human consumption, and to develop information that will assist in the assessment of other water resource projects.

4. NON-MITIGABLE IMPACTS AND ENVIRONMENTAL TRADE-OFFS

4.1 Introduction

Any alteration to the existing environment results in impacts upon the ecosystem. The change of riverine habitat to lacustrine or lake-type habitat has significant implications for the aquatic resources which presently utilize

the system. In the case of the Rafferty Reservoir, the headwater habitat of the Souris River system will undergo such a change. In this instance, a relatively small (but relatively heavily used) existing reservoir (Dead Lake) and river fishery for northern pike, yellow perch and stocked walleye will be transformed into a larger reservoir fishery. Given the high priority placed on the development of the new reservoir fishery, and the mitigatory and enhancement measures which will be incorporated into project design, non-mitigable impacts and environmental trade-offs in relation to the fishery resource are limited.

One of the goals of the project is a significant improvement in these fishery values, to the point that a desirable water-based recreational opportunity is created. Several drawbacks to the development of these opportunities have been identified in the preceeding analysis to illustrate the Authority's awareness of potential problems which exist. These concerns are common to the majority of newly created reservoirs, and a vast body of knowledge exists relating to techniques which may be employed to ameliorate the identified concerns. The Souris Basin Development Authority is committed to incorporating the necessary mitigative options into project design and operating guidelines to meet the objective of a high-quality recreational fishery in the Rafferty and Alameda Reservoirs, and downstream Souris River.

4.2 Pre-construction and Construction Activities

Non-mitigable impacts during construction of the reservoir include a loss of physical fishery habitat at the damsite and in all likelihood some or complete loss of infrequently used habitat between the damsite and Dead Lake during the construction period. Anglers who would normally use this area for fishing would have to redirect their activity to Dead Lake during the construction period. Suspended sediment loads will be increased in the Souris River during dam construction. Neither of these impacts is considered to have long-term, negative implications for the fishery resource.

4.3 Operation and Maintenance

4.3.1 Fish Habitat

Existing habitat within the reservoir area will be lost. This will include northern pike, yellow perch and possibly walleye habitat for all life stages. Spawning habitat will be replaced in the form of wetland creation at the upstream end of the reservoir, as well as through attempts to establish rooted vegetation in the drawdown zone. Walleye spawning habitat will be created on the scoured reservoir walls, as well as on the rip-rapped face of the dam, the two upstream closure dams and causeways. Spawning and rearing habitats will be created as required for the other sport fishes of interest in the reservoir fishery, such that a significant improvement in habitat availability will occur with reservoir creation.

4.3.2 Water Quality

The water quality within the reservoir may be marginal for some species. Concerted efforts will be made to improve the quality of this resource. Water quality information will be employed in the evaluation and determination of sport species to be introduced and managed in the reservoir. Stocking will be one of the trade-offs employed if difficulties are encountered in the development of a high-quality, self-sustaining fishery.

4.3.3 Downstream Habitat

Habitat alterations will occur in the aquatic environment downstream of the damsite in the Souris River. Significant opportunities exist for the enhancement of fish populations in the Souris River, given the anticipated improvements in water quality and instream flows in the system. These opportunities will be pursued, in conjunction with both the Rafferty and Alameda projects, to ensure the cumulative effects of the two reservoir developments are significant improvements in angling opportunities in terms of reservoir and river fishing opportunities.

SUMMARY OF MITIGATION, ENHANCEMENT AND MONITORING COSTS

In addition to the spring 1987 field program and the ongoing fisheries investigations in the Souris River downstream of the dams and within the proposed Alameda Reservoir, the Souris Basin Development Authority is committed to undertaking the following enhancement, mitigation and monitoring activities to maximize the potential sport fishery associated with the Rafferty Reservoir. These activities and estimates are tentative, pending results of the long-term Fisheries Management Plan. The Authority is committed to an expenditure of $650,000 for fisheries mitigation/enhancement, based on the following assumed needs:

1)	Preparation of long term Fisheries Management Plan, monitoring activities	$ 65,000
2)	Possible walleye rearing pond development and stocking of various species (over 5 years)	350,000* 30,000
3)	Piers, wharfs, boat launch ramps	100,000
4)	Shaping of gravel terraces/shoals (prior to inundation)	50,000
5)	Other fish habitat/rearing improvements	30,000
6)	Artificial reef(s)	25,000
	TOTAL	$650,000

* At this point in time, it has not been confirmed that rearing ponds for walleye will be required. The Authority will obtain further direction from fisheries biologists in Saskatchewan Parks, Recreation and Culture to confirm these expenditure requirements relative to the long-term Fisheries Management Plan.

SPRING FISHERIES INVESTIGATION OF THE SOURIS RIVER AND MOOSE MOUNTAIN CREEK

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1.0 INTRODUCTION

A fisheries investigation of the Souris River Basin in Saskatchewan, with emphasis on the proposed locations of the Rafferty and Alameda reservoirs, was conducted during April of 1987. The following data report summarizes the methods employed in the study, and the results of the sampling program.

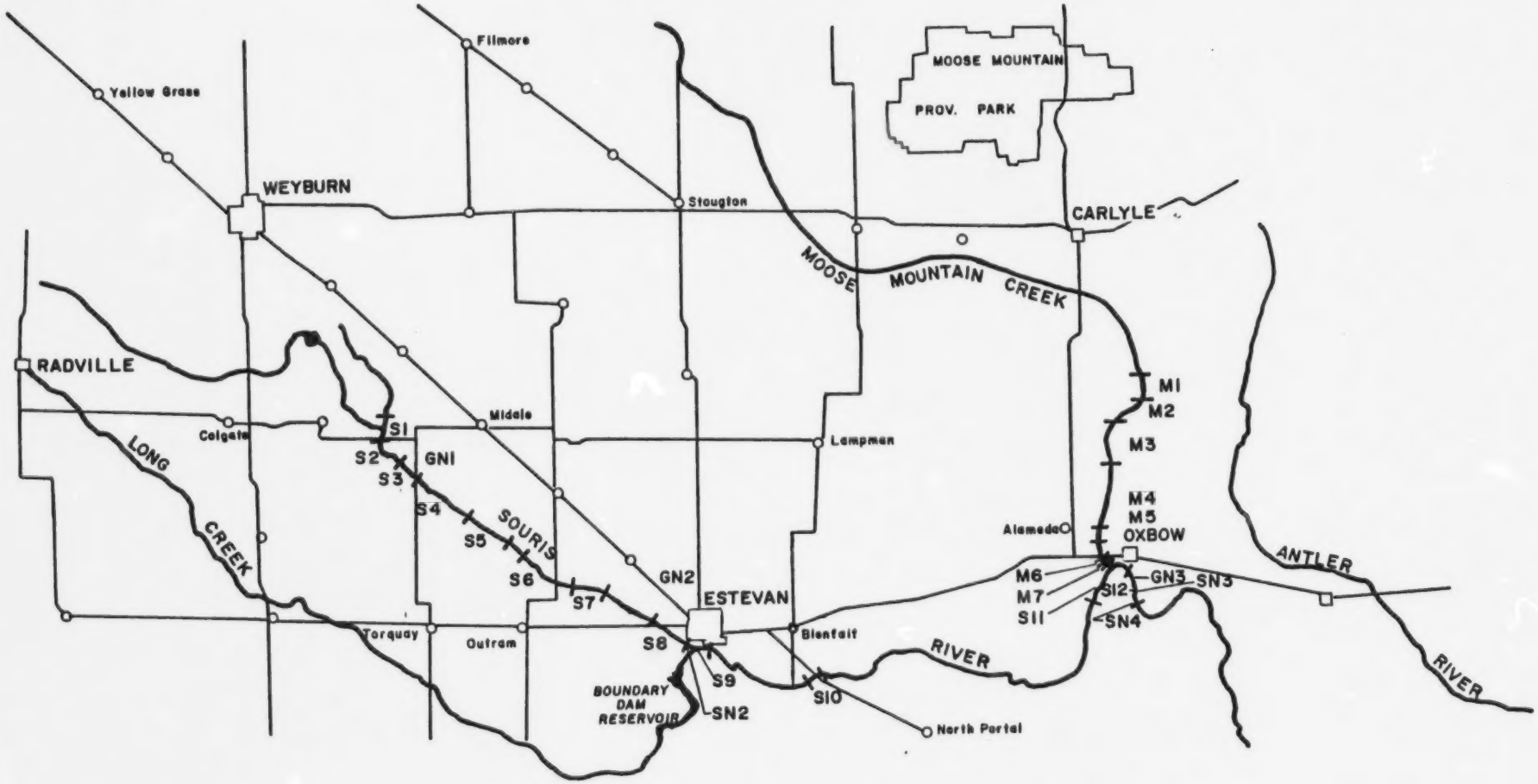
2.0 METHODS

Several techniques were employed to facilitate fisheries sampling in the Souris River and Moose Mountain Creek. Boat and backpack electrofishing were the most extensively used sampling techniques on both streams. Gill and seine netting were conducted on the Souris River only. Casual observations of fishes during other activities such as travel were also recorded. Equipment and techniques used in each type of sampling are described below.

Electrofishing

Electrofishing was conducted in several segments of each watercourse in order to sample a variety of habitats present in the Study Area. These stream segments have been numbered and are illustrated in Figure 1.

Two electrofishers were used: a 3000 watt boat-mounted electrofisher (Smith-Root model 3.5 GPP) and a battery operated backpack electrofisher (Smith-Root Type VII). The boat electrofisher was mounted on a 5.5-m long Glascon fibreglass riverboat powered by an 80-hp jet-driven Mercury outboard motor, or, where depth did not permit use of the riverboat, on a 3-m long inflatable boat powered by a 10-hp outboard motor. Both boats were used in the Souris River, while only the inflatable boat was used in Moose Mountain Creek. The backpack electrofisher was most commonly used from within the inflatable boat, facilitating investigation of long stretches of shallow stream. Use of the backpack electrofisher while wading was only conducted in Segment 6 of Moose Mountain Creek. Effort for both types of electrofishing was recorded in seconds. Catch-Per-Unit-Effort was calculated for each species and life-stage, where possible, as numbers of individuals captured per 100 seconds of sampling. All fishes captured by electrofishing were released unless samples were needed for proper species identification.



LEGEND

S(1-12) SOURIS RIVER SAMPLING LOCATION

M(1-7) MOOSE MOUNTAIN CREEK SAMPLING LOCATIONS

SN(1-4) SEINING LOCATIONS

GN(1-3) GILL NETTING LOCATIONS

FIGURE 1

FISHERY SAMPLING LOCATIONS
SOURIS RIVER BASIN
APRIL 1987

Gill Netting

Gill nets were set in three locations on the Souris River in order to sample for fish species which might not be easily captured by other methods. Most commonly, nets were set when backpack but not boat electrofishing was conducted. This ensured that large species such as walleye and northern pike, which may avoid backpack electrofishers were effectively sampled. Nets used included mesh sizes (stretched measured) of 3.8, 5.1, 7.6, 10.2 and 14.0-cm and were either 7.6 or 15.2-m long. All nets were 2.4-m deep. Duration of all sets was 24 hours extending from morning of one day to morning of the following day. All fishes captured were released unharmed if captured alive. Those individuals which were already dead were disposed of at the nearest municipal landfill site. Gill-net sample sites are presented on Figure 1.

Seining

Two beach seines were used to sample fish in the Souris River. A 7.5-m long, 1.3-m deep seine with a mesh size of 1.1 cm was used only once to sample the shoreline area of Dead Lake. All other seine hauls were conducted with a 3.0-m long, 1.1-m deep seine with a mesh size of 0.8 cm. Locations where seine hauls were conducted are illustrated in Figure 1.

Seining effort was recorded as square metres sampled (distance of haul multiplied by net width). Catch-Per-Unit-Effort was calculated for each species and life-stage as number of individuals captured per 10 m^2 of effort. Except where immediate identification was not possible, all fishes captured during seining were enumerated and released.

3.0 RESULTS

Results of electrofishing in the Souris River and in Moose Mountain Creek are presented in Tables 1 and 2 respectively. These tables include both boat and backpack electrofishing effort as indicated. Results of gill and seine netting in the Souris River are presented in Tables 3 and 4. All sample sites are as illustrated on Figure 1.

Casual observations during boat travel in the Souris River at Woodlawn Regional Park, Estevan revealed approximately 20 adult northern pike within a 2-km segment of river. Observations at the weir near Oxbow revealed concentrations of white suckers attempting to migrate upstream past the structure. Passage was not possible and many fish were stranded and dead or dying below the weir. In the vicinity of the Midale Dam on the Souris River, several juvenile black bullheads were observed either dead or in a moribund condition. The cause of this event was not apparent.

TABLE 1
SUMMARY OF ELECTROFISHING RESULTS, SOURIS RIVER, APRIL 1987

River Segment	Equipment Used[a]	Sampling Effort (s)	CATCH Total Number of Individuals/Catch-Per-Unit-Effort (No.-100 s)										
			Walleye	Yellow Perch		Northern Pike		Black Bullhead		White Sucker		Brook Stickleback
			A[b]	J	A	J	A	J	A	J	A	
S 1	BE	1152						8/0.7		2/0.2	6/0.5	100/8.7
S 2	BE	1977		1/0.1	7/0.4		2/0.1			1/0.1	15/0.8	400/20.2
S 3	BE	2218		3/0.1	22/1.0	1/0.1	1/0.1				3/0.1	Innumerable
S 4	BE	3666	5/0.1		8/0.2		4/0.1				2/0.1	Innumerable
S 5	BE	3185	8/0.3		1/<0.1		2/0.1	21/0.7		19/0.6	34/1.1	120/3.8
S 6	BE	5621		1/<0.1	2/<0.1					17/0.3		26/0.5
S 7	BE	1550									1/0.1	11/0.7
S 8	BP	1328				1/0.1				24/2.0		100/7.5
S 9	BP	1206				21/1.7	1/0.1	413/34.2		14/1.2		200/16.6
S10	BP	862							3/0.3	1/0.1	5/0.6	3/0.3
S11	BE	7544				4/0.1	10/0.1		105/1.4	17/0.2	44/0.6	100/1.3
S12	BP	3279			2/0.1		4/0.1	151/4.6	57/1.7	157/4.8	214/6.5	4/0.1

continued ...

Table 1 (concluded)

River Segment	Equipment Used[a]	Sampling Effort (s)	CATCH Total Number of Individuals/Catch-Per-Unit-Effort (No.-100 s)							
			Flathead Minnow	Common Shiner	River Shiner	Emerald Shiner	Iowa Darter	Johnny Darter	Blackside Darter	Longnose Dace
S 1	BE	1152								
S 2	BE	1977	600/30.3							
S 3	BE	2218	Innumerable							
S 4	BE	3666	Innumerable							
S 5	BE	3185	270/8.5				2/0.1			
S 6	BE	5621	34/0.6							
S 7	BE	1550	21/1.4							
S 8	BP	1328	300/22.6							
S 9	BP	1206	Innumerable							
S10	BP	862	29/3.4					2/0.2		16/1.9
S11	BE	7544	30/0.4			2/<0.1				
S12	BE	3279	72/2.2	27/0.8	1110/33.9			2/0.1	7/0.2	2/0.1

a BE - boat electrofisher
BP - backpack electrofisher

b J - juvenile
A - adult

TABLE 2
SUMMARY OF ELECTROFISHING RESULTS, MOOSE MOUNTAIN CREEK, APRIL 1987

Stream Section	Equipment Used[a]	Sampling Effort (s)	CATCH Total Number of Individuals/Catch-Per-Unit-Effort (No.-100 s)									
			Northern Pike A[b]	Black Bullhead J	Black Bullhead A	White Sucker J	White Sucker A	Brook Stickleback	Fathead Minnow	Common Shiner	Iowa Darter	Johnny Darter
M 1	BP	754				61/8.1	2/0.3	2/0.3	723/95.9			
M 2	BP	813			2/0.2	68/8.4		119/14.6	356/43.8		1/0.1	
M 3	BE	3301	3/0.1		4/0.1	215/6.5	55/1.7	870/26.4	2807/85.0			
M 4	BE	3800	2/0.1		3/0.1	273/7.2	38/1.0	438/11.5	9120/240.0			2/0.1
M 5	BE	919	2/0.2	2/0.2	1/0.1	223/24.3	22/2.4	242/26.3	700/76.2	1/0.1		
M 6	BP	567			1/0.2	25/4.4		15/2.6	75/13.2	1/0.2		
M 7	BE	240	1/0.4				14/5.8					

a BE - boat electrofisher
BP - backpack electrofisher

b J - juvenile
A - adult

TABLE 3

SUMMARY OF GILL-NET SAMPLING RESULTS, SOURIS RIVER, APRIL 1987

River Section	Net Site	Mesh Size[a] (cm)	Net Length (m)	No. of Individuals Captured					
				Walleye A[b]	Yellow Perch A	Northern Pike J	Northern Pike A	White Sucker A	Common Shiner A
S 3	GN1	14.0	15.2	1					
S 8	GN2	3.8	7.6		1	1			
		5.1	7.6		1	1			
		7.6	7.6						
		10.2	15.2						
		14.0	15.2						
S12	GN3	3.8	7.6						1
		5.1	7.6						
		7.6	7.6				4	1	
		10.2	15.2				3	23	
		14.0	15.2		1		1		

[a] Stretched measure.

[b] A - adult
J - juvenile

TABLE 4
SUMMARY OF SEINING RESULTS, SOURIS RIVER, APRIL 1987

River Section	Sample Location	Sampling Effort Area Seined (m^2)	CATCH Total Number of Individuals/Catch-Per-Unit-Effort (No.-10m^2) Brook Stickleback	Fathead Minnow	Common Shiner	River Shiner	Iowa Darter	Johnny Darter	White Sucker Juvenile	Longnose Dace
S 4	SN1	25	3/1.2	1/0.4			1/0.4			
S 9	SN2	15	2/1.3	469/312.7						
S12	SN3	18		7/3.9		74/41.1				
S12	SN3	9	2/2.2	196/217.8	41/45.6	439/487.8		6/6.7	5/5.6	
S12	SN3	21		1/0.5		63/30.0				1/0.5
S12	SN4	15		9/6.0	77/51.3	141/94.0			2/1.3	

4.0 DISCUSSION

Fish species diversity and abundance in the Souris River varied notably within the Study Area. Factors such as abrupt changes in habitat type and obstructions to fish passage appear to produce these variations. Species diversity and abundance were generally greatest immediately downstream of structures such as weirs or fords where riffles were produced and habitat diversity was greatest. Slow-moving, sometimes stagnant river segments typically had lowest diversity and abundance.

Species diversity and abundance was less variable in Moose Mountain Creek as habitat was more consistent, although several small fords were present in the stream. Fish passage to Moose Mountain Creek from the Souris River is affected by structures downstream of the confluence. The most notable of these structures is the weir at Oxbow which appears to prevent upstream migration of fishes in the Souris River and on into the creek. The railroad crossing of Moose Mountain Creek, near the creek mouth, was also judged to impair upstream fish movements. This crossing consists of a concrete arch culvert approximately 100 m long. The bottom of the culvert is concrete, as opposed to natural stream substrate, which would result in very high water velocities (likely impassible to fishes) during spring freshet.

Sport species were not abundant anywhere within the Study Area. Of the sport species present, walleye (all adults) occurred only in the vicinity of the Midale Dam and Dr. Mainprize Park. These fishes are stocked in Dead Lake at the Midale Dam, which is the likely origin of the individuals encountered. Northern pike were present throughout the system, including Moose Mountain Creek. Juvenile pike were rare or absent in most areas indicating generally low recruitment from spawning within the Study Area, although suitable habitat is available. Yellow perch were most common in the Souris River near Dr. Mainprize Park where spawning was occurring. Some yellow perch recruitment from spawning does occur, as several juveniles were captured. No perch were found between Estevan and the Oxbow weir, or in Moose Mountain Creek. Perch were again common downstream of the weir at Oxbow.

White suckers were the most abundant large-bodied species within the study area. Both adults and juveniles were common indicating successful spawning and rearing, especially in Moose Mountain Creek where suitable habitat was most available. Black bullhead was the only species of catfish encountered during this study. The species was found throughout the system, most commonly in marshy mud-bottom habitat. Abundance was greater in the Souris River than Moose Mountain Creek. Spawning and rearing is successful in both streams. Fathead minnows and brook sticklebacks were the only abundant and ubiquitous fishes within the Study Area. Both of these species prefer still water, and are hardy and tolerant of poor water quality (Scott and Crossman 1973). The three species of shiners (Family Cyprinidae) which were found within the Study Area occurred only in Moose Mountain Creek, and downstream of the confluence with the Souris River. Shiners were most abundant downstream of the weir at Oxbow. The three species of darters (Family Percidae) which were present were uncommon. Iowa darters were captured only in and near Dead Lake, and in Moose Mountain Creek. Johnny darters, which are less demanding in habitat requirements than most other darters (Scott and Crossman 1973), were more common and likely occurred in low density throughout the system. Blackside darters which prefer gravelly substrate (Scott and Crossman 1973) such as that found downstream of the weir at Oxbow, occurred only in that portion of the Study Area. Longnose dace were also rare and were captured only in riffles near Roche Percee and downstream of the Oxbow weir.

5.0 LITERATURE CITED

Scott, W.B. and E.J. Crossman. Freshwater fishes of Canada. Fish. Res. Bd. Canada Bull. 184. 966 pp.